SOI: 1.1/TAS DOI: 10.15863/TAS
International Scientific Journal
Theoretical & Applied Science
p-ISSN: 2308-4944 (print) e-ISSN: 2409-0085 (online)
Year: 2018 Issue: 07 Volume: 63
Published: 28.07.2018 http://T-Science.org

SECTION 12. Geology. Anthropology. Archaeology

E.E. Baloglanov
PhD student,
Scientific Researcher of Department of "Mud Volcanism", Institute of Geology and Geophysics, Azerbaijan National Academy of Sciences, Baku, Azerbaijan
elnur1001@mail.ru

A.N. Mamedova
PhD in Earth Sciences,
Leading Scientific Researcher of Department of "Mud Volcanism", Institute of Geology and Geophysics, Azerbaijan National Academy of Sciences, Baku, Azerbaijan

INTENSITY OF MUD VOLCANIC ACTIVITY – A HARBINGER OF EARTHQUAKE

Abstract*: Information on paroxysms of mud volcanoes and earthquakes in Azerbaijan and published materials on both events were analyzed in the article to clarify the relationship between these geological phenomena. Based on the associative model related to the proposed effects, some estimates were made to determine the minimum distances from the epicenter to the volcanic eruption and the minimum values of earthquake magnitudes. It has been established that the most important method for predicting volcanic activation associated with natural factors is to periodically study (monitoring) the chemical composition of fluids emitted to the surface. The regime studies confirm that even before small magnitudes of seismic events, some anomalies were recorded in the chemical compositions of water-mud mixture and intensity of their flows.*

Key words*: mud volcano, earthquake, model, harbinger.*
Language*: English*
Citation: Baloglanov EE, Mamedova AN (2018) INTENSITY OF MUD VOLCANIC ACTIVITY – A HARBINGER OF EARTHQUAKE. ISJ Theoretical & Applied Science, 07 (63): 148-153.
Soi: http://s-o-i.org/1.1/TAS-07-63-23 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2018.07.63.23

Introduction and a brief historical view

The issue of the influence of seismicity on mud volcanic activity in Azerbaijan has been considered in many scientific publications, beginning with the studies of G.V. Abikh on the mud volcanoes of the Southern Caspian, continued by a large team of scientists in the twentieth century and at the present time [Malinovskiy, 1938; Abikh, 1939; Akhmedbeyli, 1975; Mellors et al., 2007; Aliyev and Bayramov, 2008; Baloglanov et al., 2016; 2016; 2017]. The results of the performed studies unambiguously confirm about the genetic connection of mud volcanism with seismicity [Aliyev et al., 2001; Mellors et al., 2007; Venikova et al., 2014; Baloglanov et al., 2017; 2017; 2018; 2018].

What is the mechanism of impact? How can this be explained? In addition, what chemical changes are observed in the occurrence of two geological events, and do these changes make it possible to predict them? The proposed paper to clarify these issues on the example of the regions of Azerbaijan, which are well known with its active mud volcanoes, and the seismic zones are close enough to these volcanic areas.

The study area, and temporal-spatial characteristics

East Azerbaijan territory and the adjacent Caspian Sea belong to seismic active regions and here from time to time register strong tangible tremors, which significantly affect the activation, especially in the paroxysms of mud volcanoes. There were recorded 414 eruptions in 93 mud volcanoes over the past two centuries in Azerbaijan [Aliyev et al., 2009, 2015]. It should be noted that in a comparative analysis of data on earthquakes and recorded eruptions of mud volcanoes, it is necessary to take into account the magnitude of the earthquake, the depth of the source, the energy class, the distance between the epicenter and the volcano.

Depending on the tectonic properties of the volcanic zones, various geological factors, lithofacial and structural characteristics have different effects on the morphometric dimensions of the mud volcanoes as well as their activity forms. Tendencies in the activity of mud volcanoes and seismic intensity are associated with the possible interaction between these natural geological formations that occur as a result of geodynamic stresses on the Earth's crust. Their interaction is related to the location of adjacent

microplates, or tectonic blocks. Seismic layers are in analogous or similar geodynamic conditions in these tectonic blocks, and their waves that originated in one of them did not undergo damping before they were transferred to adjacent microblock [Aliyev et al., 2001; Abbasov and Aliyev, 2018].

Studies have shown that strong earthquakes with a magnitude of 4.5-5.0 or more points provoke eruptions of mud volcanoes. At the same time, the causal relationship is established confidently when the earthquake and mud volcano are within one fault structure and if the volcano has been at rest for a long time and has accumulated sufficient energy for the eruption paroxysm or the volcano is located in the zone of tectonic tension within a radius of 80-100 km from the epicenter of the earthquake [Aliyev, 2003; Mellors et al., 2007]. After the Caspian earthquakes of November 25 and December 6, 2000 and subsequent seismic events in the South Caspian to the south and southeast of Baku, in 2001 a record number of (16) eruptions of land and sea volcanoes was recorded in Azerbaijan.

Associative model of volcanic eruptions and earthquakes

Taking into account the magnitude, radius and temporal-spatial parameters, the correlations of the paroxysmal events of mud volcanoes with earthquakes occurred on the same day or several days ago, it was established a model that shows that which earthquake had a direct impact on the volcanic eruption in Azerbaijan. For the model, we used the empirical formula lgRmax = 0.45M-0.95 [Manga et al., 2009], which indicates the likelihood of various fluid dynamic manifestations. Used data on eruptions of mud volcanoes and recorded earthquakes taken from the table shown below (Table). As a result, four volcanic eruptions recorded twice in 1872 and 1902 (below the line) show association with earthquakes. Other eruptions (above the line) do not show a connection with recorded earthquakes (Fig. 1). In contrast to the results of published papers [Aliyev et al., 2001; Melllors et al., 2007], the corresponding magnitude for earthquakes is M≥5.5, and the distance from the erupted mud volcanoes to the epicenter varies from 20 to 50 km.

Table 1

A catalog of some registered eruptions of mud volcanoes and earthquakes in Azerbaijan

Mud volcano	Eruption date	Earthquake date	Coordinates	Magnitude	Depth (km)	Epicentral distance (km)
Kalamaddin	28.01.1872	28.01.1872	-	5.7	-	24
Shikhzarli	28.01.1872	28.01.1872	-	5.7	-	40
Bozaakhtarma	13.02.1902	13.02.1902	-	6.9	-	51
Shikhzarli	13.02.1902	13.02.1902	-	6.9	-	45
Shekikhan	15.03.2008	17.02.2008	40.11 / 49.31	2.60	34	13
		27.02.2008	40.39 / 50.32	3.00	37	96
		06.03.2008	40.65 / 49.65	2.31	6	79
Bozdag-Guzdek	13.02.2009	08.02.2009	40.33 / 49.79	2.04	45	16
		08.02.2009	40.15 / 49.99	2.12	60	41
		10.02.2009	40.48 / 50.77	2.89	56	99
Lockbatan	04.02.2010	12.01.2010	40.13 / 49.95	2.53	56	28
		14.01.2010	40.72 / 50.77	2.13	46	101
		24.01.2010	40.47 / 48.71	2.37	15	86
		30.01.2010	40.68 / 48.54	2.29	6	107
Dashmardan	12.05.2011	23.04.2010	40.33 / 50.39	2.93	52	115
		07.05.2011	40.28 / 49.12	1.88	6	10
		08.05.2011	40.38 / 49.06	1.96	38	18
Lockbatan	20.09.2012	20.09.2012	40.32 / 49.76	1.40	5	5
		20.09.2012	40.32 / 49.73	1.45	5	3
		20.09.2012	40.34 / 49.78	1.90	1.2	7
Shikhzarli	20.12.2013	06.12.2013	40.65 / 48.53	2.03	9	46
		13.12.2013	40.99 / 48.48	2.28	3	47
		18.12.2013	39.95 / 49.09	2.04	39	60
Keireki	12.10.2014	21.09.2014	41.00 / 49.88	3.01	41	59
		30.09.2014	40.14 / 48.99	2.01	43	77
		12.10.2014	40.20 / 50.14	2.15	32	41
Akhtarmaardy	26.01.2016	01.01.2016	40.15 / 49.12	2.2	21	24

		08.01.2016	40.20 / 48.60	3.1	47	22
		15.01.2016	40.29 / 48.75	1.9	7	10
Otmanbozdag	06.02.2017	26.01.2017	40.28 / 48.96	2.8	6	47
		26.01.2017	40.30 / 49.21	1.7	11	26
		06.02.2017	40.30 / 50.23	4.42	60	61
Shekikhan	06.02.2017	26.01.2017	40.28 / 48.96	2.8	6	13
		26.01.2017	40.30 / 49.21	1.7	11	11
		06.02.2017	40.50 / 48.67	2.95	13	47
Lockbatan	02.05.2017	21.04.2017	41.13 / 50.63	3.30	60	120
		28.04.2017	40.15 / 49.96	1.90	60	27
		05.02.2017	40.37 / 49.74	1.60	4	7
Shikhzarli	31.05.2017	11.05.2017	39.72 / 48.42	5.40	48	99
		11.05.2017	39.72 / 48.38	3.30	50	101
Keireki	12.06.2017	25.05.2017	40.24 / 49.17	2.30	40	58
		30.05.2017	40.81 / 51.49	3.60	44	148

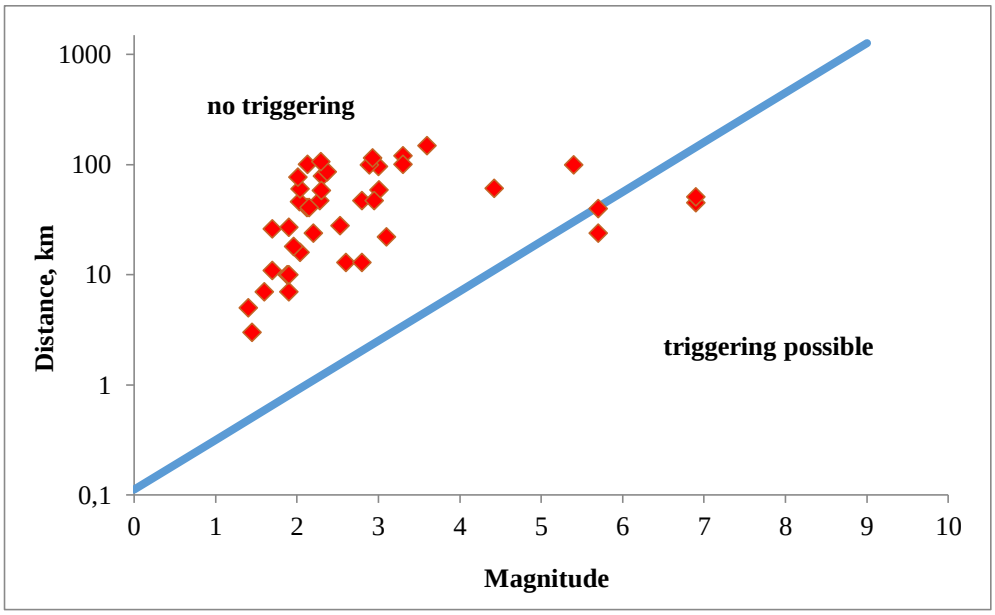


Figure 1 – Associative model of volcanic eruptions and earthquakes

Geochemical indicators for volcanic fluids and harbinger of earthquakes

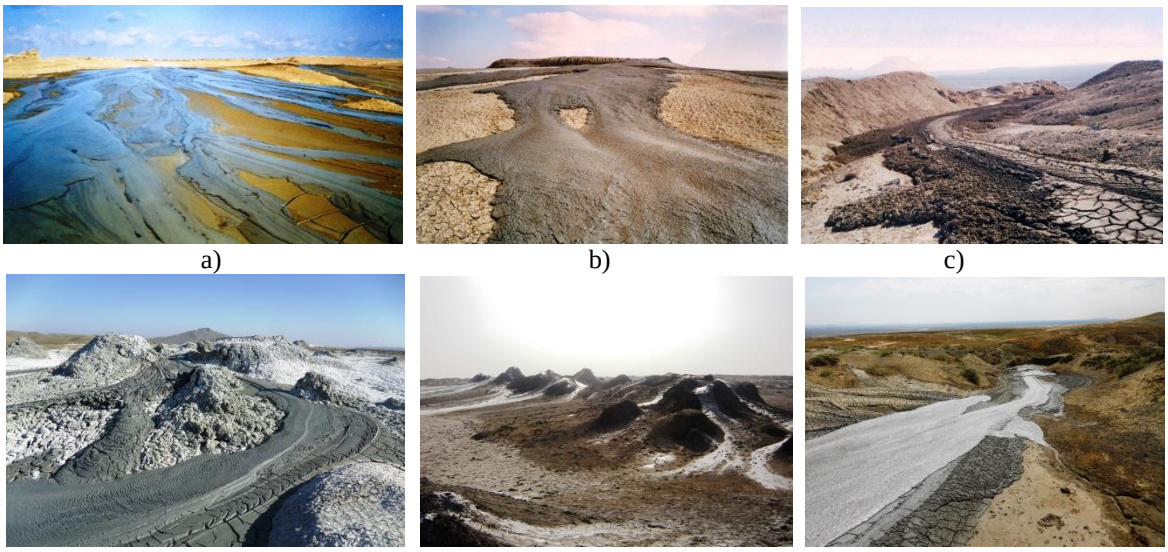
The eruption of the mud volcano, first of all, depends on its own activity, but one of the additional external factor is also an earthquake. The activity of the volcano is caused by the outflow of gas from the mud volcanic reservoir through disjunctive disturbances in the earth's crust, which serve as a volcanic channel. The process of displacing the water-mud mixture overlapping the volcano channel with gas takes quite a certain time, which will depend on the geometry of the channel and the physical properties of the gas and water mud mixture.

In the world practice there are not yet sufficiently detailed results of studies in the field of forecasting eruptions of mud volcanoes. As a result of visually established changes in the crater field of the mud volcano, as well as observing the intervals of eruptions that occurred after the high-magnitude earthquakes recorded in the region, in some cases it is possible to forecast possible eruptions, but this method is not sufficient for more accurate prediction of eruptions of mud volcanoes. In our opinion, the most productive approach for investigating the relationship between mud volcanism and seismicity should be considered monitoring observations of gryphon-salse activity of mud volcanoes.

At the same time, the inverse relationship between the activation of mud volcanic activity and seismicity has also been established. Activation of the calm gryphon-salse stage of mud volcano activity occurs before seismic events, as in the preparation of weak earthquakes to 3.5-4.0 points on the Richter scale. In Azerbaijan for the first time this relationship was established in the 80s and early 90s of the last century, when monitoring was carried out on the mud volcanoes of the Shamakhi-Gobustan seismically

active area, from measurements of fluid flow rates, the study of gases, and water from 2-3 gryphons on the volcano. Daily and weekly observations of changes in the chemical composition of fluids were determined, and the obtained data were compared with the number of weak earthquakes. As a result, some gas hydrochemical indicators were found that cause the activation of mud volcanoes before these weak earthquakes [Aliyev et al., 1989; Aliyev, 1992]. At the last stage of earthquake preparation, some values in the chemical composition of gases and waters (CO_2, He, B, Cl and SO_4) increase due to the deep flow of liquids.

Similar study was carried out at the beginning of the new millennium. For clarity, we present some results of the studies performed. A strong activation was observed on the island volcano Garasu (Fig. 2a) on September 12, 2001. 10 days before the earthquake with a magnitude of 4.1 points in the north of the Baku archipelago. On the SW of Absheron Peninsula on the mud volcano of Pilpila Garadagh (Fig. 2b), an unusual mud flow was observed on October 16, 2002. An earthquake of 3.8 points occurred near the shore of the sea in the Baku archipelago on October 27. In the same month on October 29, on the volcano Agzybir (Fig. 2c) located in the east of the Lower Kura depression, close to the sea band, an outpouring of mud volcanic breccia was recorded, before the November 11th weak earthquake (3,2 points) also in the Baku archipelago. A powerful outpouring of copious dirt was recorded in Central Gobustan (Bayanata microblock) on the volcano Kichik Maraza (Fig. 2d) two days before the earthquake on July 19, 2007, which occurred near the place of activation of the volcano. Such proximity of the epicenter of the earthquake that took place on February 20, 2009 near the northern part of the Baku archipelago, in the Alat region, was noted after the noticeable intensification of the activity of the mud volcano Dashgil (Fig. 2e) in South Gobustan (Toragay microblock), etc. On May 13, 2018, a strong flow was recorded in the mud volcano Yandara (Figure 2f), located in the Lower Kura region. Three days after this event (on May 16, 2018), earthquake occurred at 55 km from the volcano with magnitude 3.2 in Saatli region. There are many such examples, which allow us to consider an increase in the flow rate of emitted water-mud mixture, anomalous changes in some components of the composition of fluids are harbingers of earthquakes.



a) b) c)

d) e) f)

Figure 2 – Activation in some mud volcanoes before recorded earthquakes:
a – Garasu mud volcano, b – Pilpile-Garadag mud volcano, c – Agzybir mud volcano,
d – Kichik Maraza mud volcano, e – Dashgil mud volcano, f – Yandere mud volcano.

Starting from the first months of 2017, along with the increase in seismic tensions in the territory of Azerbaijan, the eruption of mud volcanoes has also increased. Hydrochemical monitoring was carried out for 10 volcanoes (Dashgil, Shikhzarli, Durovdag, Uchtepe, etc.) on Shamakhi-Gobustan, Lower Kura and Absheron oil-gas bearing regions from April to July of this year. In the indicated period of time, periodically (once a week) samples of water-mud mixture were taken and temperatur were measured. Evaluation of the activity of the investigated sopka was made visually relative to the flow rate of the water-mud mixture and gas. Determination of the chemical composition of waters from sopka and the concentration of basic anions and cations is performed by atomic spectroscopy, ion chromatography and titrimetry. During the monitoring period, the composition of some water

components (B, SO_4, Cl) increased abnormally, temperature of water from sopka changed sharply as well. As a result, it was established that after two successive earthquakes occurred on May 11, 2017, with magnitudes of M = 5.4 and M = 3.3, respectively, on May 31 of the same year was an eruption of the mud volcano Shikhzarli.

Conclusion

It is confirmed that a relatively better method for predicting of eruptions of mud volcanoes is periodic chemical studies on volcanic fluids. An increase in the flow rate of emitted water-mud mixture, anomalous changes in some components of the composition of fluids are harbingers of earthquakes.

In contrast to the results of the published works, it was found that seismicity can affect the eruption of mud volcanoes when its magnitude is M≥5.5, and the distance from the erupted mud volcanoes to the epicenter varies from 20 to 50 km.

Acknowledgments

Many thanks to prof. Adil Aliyev from the Institute of Geology and Geophysics, Azerbaijan National Academy of Sciences, as well as PhD in Physical and mathematical sciences Valery Ershov from the Institute of Marine Geology and Geophysics of the Far East Branch of the Russian Academy of Sciences for effective logistical support and scientific advices.

References:

1. Abikh G.V. (1939) O poyavivshemsya na Kaspiyskom more ostrove i materialy k poznaniyu gryazevykh vulkanov Kaspiyskoy oblasti (perevod s nemets, yaz.) // «Tr. Geol. in-ta AzFAN SSSR», 1939. T. 12/63, pp. 21-118.
2. Akhmedbeyli F.S. (1975) Sovremennaya aktivnost gryazevykh vulkanov vostochnoy chasti Azerbaydzhana i ee svyaz s seysmichnostyu // Doklady Akademii Nauk Az. SSR, 1975. T. 31, № 8, pp. 61-64.
3. Aliyev Ad.A., Gasanov A.G., Kabulova A.Y., Abbasly A.A. (1989) Gryazevye vulkany i seysmichnost Shemakhino-Gobustanskogo rayona // Materialy yubileynoy sessii, «Posvyashchennoy 50-letiyu IGANA». Baku, 1989, pp. 215-217.
4. Aliyev Ad.A. (1992) Geokhimiya gryazevykh vulkanov i neftegazonosnost bolshikh glubin // Avtoreferat doktorskoy dissertatsii. Biblioteka IGNANA, 1992, pp. 49.
5. Aliyev Ad.A., Gasanov A.G., Bayramov A.A., Belov I.S. (2001) Zemletryaseniya i aktivizatsiya gryazevulkanicheskoy deyatelnosti (prichinnaya svyaz i vzaimodeystvie) // Trudy In-ta geol. NAN Azerb. Baku: Nafta-Press, 2001. № 29, pp. 26-38.
6. Aliyev Ad.A. (2003) Gryazevoy vulkanizm Yuzhno-Kaspiyskogo neftegazonosnogo basseyna // Trudy IGNANA, Izd-vo «Nafta-Press», 2003. № 31, pp. 21-47.
7. Aliyev Ad.A., Bayramov A.A. (2008) Vliyanie seysmichnosti na gryazevoy vulkanizm Azerbaydzhana i nekotorye paradoksy // Trudy In-ta geol. NAN Azerb. Baku: Nafta-Press, 2008. № 36, pp. 40-51.
8. Malinovskiy N.V. (1938) Seysmy, soprovozhdayushchie gryazevye izverzheniya // Tr. AzFAN SSSR, seriya fiziko-matematicheskikh nauk. 1938. T. 3/38, pp. 65-74.
9. Aliyev Ad.A., Guliyev I.S., Rahmanov R.R. (2009) Catalogue of recorded of mud volcano eruptions of Azerbaijan (1810-2007). Second edition. Baku: Nafta-Press, 2009. 109 p.
10. Aliyev Ad.A., Guliyev I.S., Dadashov F.H., Rahmanov R.R. (2015) Atlas of world mud volcanoes. Baku: Publishing house «Nafta-Press», «Sandro Teti Editore», 2015, 321 pp.
11. Baloglanov E.E., Abbasov O.R., Akhundov R.V. (2016) Gas-Hydrochemical Indicators of Mud Volcanism Communication with Seismicity // XXIII International Scientific Conference of Students, Post-Graduates and Young Scientists «Lomonosov-2016». Moscow, Aprel 11-15, 2016, pp. 1.
12. Baloglanov E.E., Abbasov O.R., Akhundov R.V et al. (2016) Seismic activity and changing regularities of fluid geochemical indicators in mud volcanoes (on the basis of mud volcanoes data in Shamkhi-Gobustan (Azerbaijan) and Sakhalin Island (Russia) // International Youth Forum “Integration Processes of the World Science in the 21th Century”. Ganja, October 10-14, 2016, pp. 96-99.

13. Baloglanov E.E., Abbasov O.R., Akhundov R.V., Nuruyev I.M. (2017) Daily gryphon-salse activity of mud volcanoes and geo-ecological risk (based on researches, conducted in Gaynarja mud volcano) // Water resources, hydraulic facilities and environment. Baku, 2017, pp. 512-517.
14. Baloglanov E.E., Abbasov O.R., Akhundov R.V., Huseynov A.R., Abbasov K.A., Nuruyev I.M. (2017) Daily activity of mud volcanoes and geoecological risk: a case from Gaynarja mud volcano, Azerbaijan // European Journal of Natural History. 2017. Issue 4, pp. 22-27.
15. Baloglanov E.E., Abbasov O.R., Akhundov R.V., Abbasov K.A., Nuruyev I.M. (2017) Impact of seismic activity on fluid (gas and water) and temperature regimes of mud volcanoes in Shamakhi-Gobustan region (Azerbaijan) // Proceedings of the VII Youth Scientific Conference «Ideas and Innovations in Geosciences». Kyiv, October 25-27, 2017, pp. 31.
16. Baloglanov E.E., Abbasov O.R., Akhundov R.V., Hasanov E.H., Abbasov K.A., Nuruyev I.M. (2018) Anomalies in gas-hydrogeochemical indicators of mud volcanoes in connection with seismic activity: on the basis of mud volcanoes data in Shamakhi-Gobustan (Azerbaijan) and Sakhalin Island (Russia) // ISJ Theoretical & Applied Science. 2018. Vol. 57, issue 01, pp. 176-185. Doi: https://dx.doi.org/10.15863/TAS.2018.01.57.32
17. Baloglanov E.E., Abbasov O.R., Akhundov R.V. (2018) Hydrochemical changes in mud volcanoes: a precursor of earthquakes // XXV International Scientific Conference of Students, Post-Graduates and Young Scientists «Lomonosov-2018». Moscow, Aprel 9-13, 2018, pp. 1.
18. Manga, M., M. Brumm, and M. L. Rudolph (2009). Earthquake triggering of mud volcanoes, J. Mar. Pet. Geol., Vol. 26(9), pp. 1785-1798.
19. Mellors R., Kilb D., Aliyev A., Gasanov A., Yetirmishli G. (2007) Correlations between earthquakes and large mud volcano eruptions // Journal of Geophysical Research. 2007. Vol. 112. B04304. doi:10.1029/2006JB004489. pp. 1-11.
20. Orhan Abbasov and Adil Aliyev (2018) Geodynamic stresses and eruption paroxysm of mud volcanoes // European Geosciences Union General Assembly 2018, Geophysical Research Abstracts. Vol. 20, EGU2018-6467. Vienna, April 8-13, 2018.
21. Venikova A.L., Obzhirov A.I., Abbasov O.R., Baloglanov E.E., Akhundov R.V. (2014) Mud volcanism and seismicity (based on a comparative analysis of geochemical data of mud volcanoes located on Sakhalin Island of the Russian Federation and Shamakhi-Gobustan District of Azerbaijan) // 1st International Scientific Conference of Young Scientists and Specialists «The role of multidisciplinary approach in solution of actual problems of fundamental and applied sciences (Earth, technical and chemical)». Baku, October 15-16, 2014, pp. 5-8.